Learning Segment 2.0
The Sandwich-Cookie Challenge

Overview

Have you ever wished that you could have a bite-size version of your favorite sandwich cookie? What would the company who makes these cookies need to know to be able to make a good product? Your next challenge will be to help the company develop a mini sandwich cookie. You will work with others to meet this challenge. While working on the challenge, you will learn more about scientific investigations.

Activity: How Do You Know Your Answer Is Right If You Don't Know The Right Answer?

The cookie company needs to know the cost of making a mini sandwich cookie. This will depend partly on the cost of the ingredients that make up the cookie. The company needs to know the amount of cream filling that will be placed on each cookie. You will test a cookie the size of a penny. The cookie must look like it has lots of filling. However, the filling cannot go over the sides.

The experiment question is: *How much filling can be placed on the bottom cookie so it is completely covered but doesn't leak over the sides?*

The project is being sent to three labs. At your lab, you are assigned the job of finding how many drops of cream filling can be placed on the cookie without leaking. If your factory is chosen to produce the new product, it will bring in new jobs. It is important that you give this project your best effort!

Procedure

You will work with a partner on this challenge. You will be given materials to imitate the dropping of cream filling onto the cookie. You will use a penny, a pipette (similar to an eyedropper), and a cup of water. You will determine how much water fits onto the surface of the penny. Assume that this is the same as how much cream filling will fit on a cookie the same size as the penny.

Before you start your tests, complete the following two tasks:

1. As a class, identify the criteria and constraints of the challenge. Your teacher will record them on poster paper so that you may revisit them later.
2. With your partner, meet and discuss a procedure you could use to answer the question. Each person should record the procedure on a sheet of paper. Your teacher will provide you with a set of materials that you will have available. You will have about 5 min. to put together a procedure.

Once you have completed these two tasks, follow your procedure. Obtain results for ten trials. Record these results on the same sheet of paper as your procedure. Be prepared to share your results with your class and teacher. You will have 10-15 min. to perform your procedure and obtain your results.

Communicating Results

Share and Analyze the Sandwich-Cookie Data

Your teacher will give you a sheet of graph paper to record the data that everyone collected. Remember, your class is a working laboratory. You are competing with others to get the job. It is important to show that your class has a good idea of how many drops fit on the cookie.

By creating a type of graph called a **histogram** you will be able to demonstrate that your lab can:

- accurately determine the correct amount of filling for the cookie, and
- reproduce the same result over and over.

A histogram is a special type of bar graph. Your teacher will discuss with you how a histogram works. Then, each group will read aloud their results. Everyone will chart them on the histogram.

Reflection Questions

Review the following Reflection Questions. Have your written procedure available as you answer the following questions.

1. Did your group have any problems (mistakes, spills, etc.) during the tests? Describe each one.
2. Did all groups get results similar to yours?
3. What did the distribution, or spread, of data points on the histogram look like? What do you think this says about how reliable your lab is in determining the answer to the cookie company's question?
4. Why do you think there are differences between the data from various groups?
5. How might ~~your~~ the procedure and problems you had relate to the differences?
6. What could the class do to get more consistent results in this challenge?

Learning Segment 2.1
Rethinking Your Tests

Overview

It's possible that you and your classmates disagreed on how much water can fit on the surface of a penny. Today you will see if you can find a way to make the results of the groups more consistent.

What Went Wrong?

Your histogram may have shown that your lab cannot produce reliable results. You may also have noticed that every group was not using exactly the same procedure. Is it possible that this might explain the differences in the data?

When you run an experiment, choosing what you measure is important. It is also important to decide how to make your measurements. For some experiments, there are many different ways to answer your experiment question. For example, suppose you measure "plant growth." You could measure height, weight, number of leaves, number of roots, and so on. It's important that you define your measurements.

It's also important that the measurement is something you can do. For example, your school may not have the equipment that would help you observe or measure something accurately. Therefore, you may not be able to answer the experiment question. If you do have the right measurement equipment, make sure to use it correctly.

In the same way that you need to be very consistent with how you conduct each part of the experiment, you also need to be consistent with how you measure outcomes. For example, suppose you want to measure plant growth in different lighting conditions. Another researcher wants to measure plant growth when different types of soil are used. If you start by measuring plant growth by height, and the other researcher measures plant growth by number of leaves, it's hard to compare the effects of each factor (soil type and lighting conditions) if each researcher does not measure the effect in the same way.

If you know that certain types of measures are going to be used by others doing similar research, it's a good idea to stick to the same types of measures, so you can make such comparisons easily.

Here is a checklist that you can use to make sure you have consistency in your measurements and procedure:

- Measure from the same point.
- Measure with the same units.
- Use similar measures to what other people use.
- Repeat trials for accurate tests.
- Start fresh. Don't compare data from before you make changes to data that comes after you make changes.
- Measure under the same conditions.

This last point is important to your Sandwich-Cookie Challenge. What were the conditions in which you measured the number of drops? Some of the groups may have done X. Some groups may have done Y. Others may have done Z. Every group was completing a similar procedure, *but the procedures were probably not identical.*

Your teacher will lead you through a discussion where you will identify all of the aspects and steps in the testing procedure. You will discuss how to carry out each step. Then you will agree upon one class testing procedure.

Your teacher will record and display the new procedure. You will need to record this procedure and keep it handy.

Reflection Questions

Review and answer the following questions.

1. What are three or four key differences between your previous procedure and the new class procedure?
2. What variables are you now better controlling in the new procedure?
3. In your opinion, what effect will this new procedure have in the variation of the data on the histogram?

Learning Segment 2.2
Re-Testing Your "Cookies"

Overview
Now that you have a new procedure in place, can your lab produce more reliable results? Today you will conduct ten trials and the class will produce a new histogram.

Activity: Run Your New Sandwich-Cookie Test

Procedure
As a class, update the criteria and constraints of the challenge. Your teacher will record them on same poster paper you created earlier.

Your teacher will provide you with a set of materials that you can use. Follow your procedure. Obtain results from 10 trials. Record these results on the same sheet of paper as your procedure. Be prepared to share your results with your class and teacher. You will have 10-15 min. to perform your procedure and obtain your results.

Communicating Results: Share and Analyze the Cookie Data
Your teacher will provide you with another sheet of graph paper to record the data that everyone collected. Remember, your class is working in a lab that is trying get the job of making cookies. It is important to show that your class has a good idea of how many drops fit on the cookie.

Each group will read aloud their results. Then everyone will chart them on the histogram. Review the histogram. Compare its distribution of data points to that of the first histogram.

Room for Improvement?
You and your classmates will have some time to discuss how the new procedure brings you closer to the answer. You might find that there are still some differences in procedure and measurement. Come up with fixes to create an even better procedure.

Use the new procedure. Try to see if you can produce a third set of data that is more consistent. Be sure to run your procedure under the same conditions as you did before. Your teacher may ask you to do this part of the activity at home.

Use the last set of data you produced. Create a third histogram to compare the data.

Reflection Questions

1. How do the results from the last test compare to the ones from your first set of trials?
2. Did you have any problems (mistakes, spills, etc.) during the tests? List them.
3. Did all groups get results similar to yours?
4. What did the distribution, or spread, of data points on the histogram look like? What do you think this says about how reliable your lab is in determining the answer to the cookie company's question?
5. Do you think it would ever be possible, given the materials and conditions you have in the classroom, to find the "right" answer? Why or why not?
6. What do you think it would take to find the "right" answer?

What's the Point?

Over the past few days, you and your classmates have been trying to find the answer to a question. In the end, you found that it wasn't possible to find the "right" answer. Various things prevent you from being exact. These include the environment, the tools you had available, or the method you used. But as the different groups in the class used ~~more~~ increasingly similar procedures, their answers got closer to each other. You found that the way you collect data affects the answers you can find.

The first time everyone tried to determine the number of drops of water that would fit on a penny each group had different results. That is because each group used a similar method, but not an identical method. The class then worked together to come up with a standard procedure. When everyone followed the standard procedure, everybody's answers were closer to each other. From this, you learned how important it is to create one standard procedure. Also, you learned that it is important to follow the procedure carefully each time. Your data then became more consistent.

There are three likely sources of inconsistent data:

1. Human error – You perform an action in the procedure differently between tests.
2. Tools or environment – Your tools or the conditions change between tests.
3. Inability to be exact – You or your tools might not be as exact as you would like. (For example, you don't know if every water drop was the same size.)

None of these are an excuse for submitting bad data as evidence for a conclusion. But thinking about why data you collect is not exact might help you make a procedure better or realize that you need different tools. As you progress through future investigations and challenges in this class, you will be required to create consistent procedures and follow them consistently. You will participate in discussions where your teacher and your classmates will carefully review the consistency of your procedures and the data they produce.